# T08D04 – (18.1) AB Calcs ****Notes****

Name ……………………………………………………..

1. 18.1.1 State the expression for the ionic product constant of water (Kw). (1)
   1. Provide an equilibrium equation for water and the ionic product constant equation for water:
   2. Pure water has the same concentration of what two ions in solution? What is it at 25oC?
2. 18.1.2 Deduce [H+(aq)] and [OH–(aq)] for water at different temperatures given Kw values. (3)
   1. What happens to the value of Kw as temperature changes? Explain, complete the table, and provide a rough graph of the effect of temperature on Kw:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Temperature** | **0oC** | **25oC** | **40oC** | **100oC** |
| **Kw (mol2dm-6)** |  |  |  |  |

* 1. How does this affect the values of [OH-] and [H+] in solution?
  2. How does this affect the pH of solutions?
  3. Explain, using principles of energetics and equilibrium, why the dissociation of water is an endothermic process:
  4. At 60oC, the ionic product constant of water is 9.6x10-14 mol2dm-6. Calculate the pH of a neutral solution at this temperature

1. 18.1.3 Solve problems involving [H+(aq)], [OH–(aq)], pH and pOH. (3)
   1. *This material was covered in SL Topic 08, for review please revisit those notes for details*
   2. Calculate the pH of 0.01 mol dm-3 NaOH(aq):
   3. Calculate the pH of 0.01 mol dm-3 Ba(OH)2
   4. Calculate the pH of 0.01 mol dm-3 sulfuric acid: *Hint: think about the strong/weak properties of sulfuric acid and it’s conjugates as it’s deprotonated*
   5. A solution of HNO3(aq) contains 1.26g of the pure acid in every 100cm3 of aqueous solution. Calculate the pH of the solution
   6. A solution of NaOH(aq) contains 0.40g in every 50cm3 of aqueous solution. Calculate the pH of the solution
   7. Briefly explain (no need to show all the work), using 1.0x10-8 mol dm-3 HCl(aq), why solutions of dilute acids can cause issues with pH calculations:
   8. Although we will not use the following cases in IB chemistry, provide examples of an acid and a base that reach beyond the 0-14 pH scale range:
2. 18.1.4 State the equation for the reaction of any weak acid or weak base with water, and hence deduce the expressions for Ka and Kb. (1)
   1. Deduce the following expressions:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **What is it?** | **How is it calculated** | **How would you get to pKa, pKb, or pKw respectively?** |
| **Acid Ionization Constant (Ka)** |  | *Chem Eqn:* | *Ka🡪pKa* |
| *Eq. Expression:* | *pKa🡪Ka* |
| **Base ionization Constant (Kb)** |  | *Chem Eqn:* | *Kb🡪pKb* |
| *Eq. Expression:* | *pKb🡪Kb* |
| **Ionic Product Constant for Water (Kw)** |  | *Chem Eqn:* | *Kw🡪pKw* |
| *Eq. Expression:* | *pKw🡪Kw* |

* 1. Complete the following table for strong and weak acids and bases, noting which will have high or low values of Ka, Kb, pKa, pKb, etc

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Strong Acid** | **Weak Acid** | **Strong Base** | **Weak Base** |
| **Values for the reactant** | Ka:  pKa: | Ka:  pKa: | Kb:  pKb: | Kb:  pKb: |
| **Values for its CONJUGATES** | Kb:  pKb: | Kb:  pKb: | Ka:  pKa: | Ka:  pKa: |

* 1. Show, using equilibrium equations, how the equilibrium constants for acids and bases, Ka and Kb respectively, change for strong and weak materials:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Strong Acid** | **Weak Acid** | **Strong Base** | **Weak Base** |
| **Equilibrium Expression** |  |  |  |  |

* 1. How can the pH of the following be calculated?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Strong Acid** | **Weak Acid** | **Strong Base** | **Weak Base** |
| **How to Calculate pH** |  |  |  |  |

* 1. We make a very important assumption in dealing with weak acid and base calculations, explain how **assumptions are for the weak:**

1. 18.1.5 Solve problems involving solutions of weak acids and bases using the expressions: Ka × Kb = Kw, pKa + pKb = pKw, pH + pOH = pKw. (3)
   1. *Included in SL calcs and below in further calculations.*
2. 18.1.6 Identify the relative strengths of acids and bases using values of Ka, Kb, pKa and pKb. (2)
   1. What does I.C.E. stand for and how does the chart help us to organize our calculations?

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

* 1. Calculate the pH of a 1.00 mol dm-3 aqueous solution of hydrofluoric acid, HF(aq), given that the acid dissociation constant for HF is 7.2x10-4

HF(aq) ⇌ H+(aq) + F-(aq)

Ka =

|  |  |  |  |
| --- | --- | --- | --- |
|  | **HF(aq) M** | **H+(aq) M** | **F-(aq) M** |
| **Initial** |  |  |  |
| **Change** |  |  |  |
| **Equilibrium** |  |  |  |

Ka =

Ka = 7.2x10-4 =

Calculate the pH value using both the quadratic approach and the assumption, and then compare the two:

For the assumption:

x2 = 7.2x10-4 x 1.00

x =

x = 2.68x10-2

x = [H+]

-log[H+] = pH

pH = **1.57**

If no assumption, solve quadratic:

x2 + (7.2x10-4)x - (7.2x10-4 x 1.00) = 0

ax2 + bx + c = 0

a = 1

b = 7.2x10-4

c = -7.2x10-4

= 2.65x10-2 = [H+]

-log[H+] = pH = **1.57**

* 1. Things to know about pK values:
     1. pKa and pKb numbers are usually positive w/o units
     2. Stronger acids or bases with high values for Ka or Kb have lower values for pKa and pKb respectively
     3. A change in one unit of pKa or pKb represents a 10-fold change in the value of Ka or Kb
     4. pKa and pKb must be quoted at a specific temperature, generally 25oC for standard conditions and measurements
     5. High values of Ka for an acid will have low values of Kb for its conjugate base (make sense?)

Ka • Kb = [H+][OH-] = Kw

* 1. Complete the following tables to explain how the Ka and pKa and the Kb and pKb are related:
     1. For Acids:

|  |  |  |  |
| --- | --- | --- | --- |
| **Acid** | **Formula** | **Ka** | **pKa** |
| **Methanoic** |  |  |  |
| **Ethanoic** |  |  |  |
| **Propanoic** |  |  |  |

* + 1. For Bases:

|  |  |  |  |
| --- | --- | --- | --- |
| **Bases** | **Formula** | **Kb** | **pKb** |
| **Ammonia** |  |  |  |
| **Methylamine** |  |  |  |
| **Ethylamine** |  |  |  |

* 1. Calculate the Kb for a 0.100 mol dm-3 aqueous solution of methylamine, CH3NH2, at 25oC. Its pH is 11.80 at this temperature
  2. A 0.20 mol dm-3 aqueous solution of ammonia has Kb of 1.8x10-5 at 25oC, what is the pH?